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Parallel Imports and Innovation in an Emerging Economy[*]

Andrea Mantovani[†] Alireza Naghavi[‡]

Abstract

This paper studies the consequences of parallel import (PI) on process innovation of firms heterogeneous in their production technology. In an international setting where foreign markets differ with respect to their intellectual property rights regime, a move by a technologically inferior firm to exploit a new unregulated market can result in imitation and PI. The impact of PI on innovation is determined by the degree of heterogeneity between firms and trade costs. Increasing trade costs shifts from the market share losses brought by PI from the more to the less productive firm. This induces the former to invest more in R&D. At this point, sales in the foreign market become a determinant of the R&D decision by the technologically inferior firm. For low levels of firm heterogeneity, PI increases output by this firm targeted for the unregulated market, hence increases its Innovation efforts. A tariff policy accompanied by opening borders to PI only increases welfare when the technological gap between the two firms are sufficiently large.

Keywords: Intellectual property rights, Parallel imports, Innovation, Trade costs, Welfare

JEL Classification: F12, F13, L11

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1 Introduction

The debate about parallel imports (PI) and the views on their impact in the global economy have become increasingly controversial in recent years. Generally defined, PI are unauthorized re-imports of genuinely produced commodities back to the country of the original producer. The issue has by and large been associated with price discrimination, vertical price control, and national price regulations.[1] When goods sold by a patent holder to a foreign market at a lower price are imported back to the original country, the producer faces competition with its own goods offered at a lower price. This also reveals an important connection between PI and the protection of intellectual property rights (IPR).

In this paper, we aim to explore the effect of PI on innovation in emerging economies with TRIPS obligations to upgrade their IPR regime. Entering a market where IPR are not respected enables foreign manufacturers to imitate and send a part of their output back to the original market to exploit an arbitrage opportunity. While consumers may gain from lower prices, this may provoke consequences on the innovative behavior of different type of firms, and hence the fate of the industry.

The Patent Act 2005 of India created major concerns in the pharmaceutical industry, one of its greatest points of strength since decades. While generic drugs have been freely and skillfully produced in India, the Patent Act prohibited the production of generics whose patents have not expired.[2] On the optimistic side, this can be a first step towards taking a leading role in innovating original medicine. It could however be accompanied by a sudden surge in prices of pharmaceuticals in India and hence limited access to medicine by a great portion of the population.

Interestingly, according to the TRIPS agreement each WTO member has the sovereignty to choose its own policy on PI. This could be seen as an opportunity to mitigate the negative effects of IPR protection on consumers, made possible by allowing imports of generic products from a market still unregulated in terms of IPR. There have been rather skeptic views with regards to PI in the international trade literature, precisely for cases such as the rapidly evolving Indian pharmaceutical industry. In particular, an important question that has been raised is: "does allowing PI reduce R&D by Indian pharmaceuticals, and thereby impede the road taken towards the development of its own innovative rather than an imitative phar-

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[1] See Maskus and Chen (1994), Richardson (2002), Valletti (2006), Ganslandt and Maskus (2007) and Grossman and Lai (2008).

[2] All patents registered before 1995 cannot be protected in India despite being protected elsewhere. Therefore, they could still be produced as generics in India.

maceutical industry?"

To account for the particular characteristics of the Indian pharmaceutical industry, we separate the market into two groups: (i) large scale companies such as Ranbaxy, Dr. Ready, or Cipla, which pursue a catch up strategy by engaging in innovation in order to challenge leading firms in developed countries; (ii) medium firms such as Lincoln, Simrone, and Aurochem, commonly referred to as specialized operators.[3] Both types of firms possess patents, but differ with respect to their R&D capabilities. The more efficient large scale companies are competent to enter less risky regulated markets such as the US or the EU. On the other hand, medium firms are technologically inferior and seek new unexploited markets to compensate for their competitive disadvantage. Such destination markets are often unregulated, where local manufacturers can reproduce and sell imitation products back in the original market.

A good example of such unregulated market is Tanzania, which under TRIPS is not required to enforce IPR in pharmaceuticals until 2016.[4] In addition, it is the only new frontier in Africa since 2002 with capabilities to replicate active principle ingredients (API) besides Egypt, which has been active since 1992. There are 32 other African countries, which are only capable of producing formulations. As formulation manufacturing already exists in Tanzania, workers in Indian subsidiaries may defect and disseminate information to local manufacturers. They can then use their absorptive capacity to produce the similar final good that contains the patented API and sent it back to India.

The literature on the impact of PI on innovation is rare and mostly focuses on the R&D decision of a monopolist when its distributor engages in PI. Innovation has been modelled in several forms with mixed results. Valletti and Szymanski (2006) look at product innovation, where more R&D translates into higher quality products. They find the impact of PI to be negative on R&D incentives, even if the monopolist may introduce a new lower quality brand to compete with the generic drug. Li and Robles (2007) instead find the conditions under which PI increases incentives to innovate a new horizontally differentiated version of the product. Li and Maskus (2006) consider cost reducing process innovation and show that PI always inhibits R&D. Li (2006) adds to this by examining competition between two symmetric firms in the home country and finds ambiguous results on innovation that depending on

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[3] See Chaudhuri (2005a, 2005b).

[4] India holds the highest number of registered patents in Tanzania and accounts for 1315 drug products registered there in 2007, which is more than one third of the total. Kenya is ranked second with 307 registered drugs. See Chaudhuri (2008) for more details.

transportation cost. The results in the above work are derived under the implicit assumption that IPR are perfectly enforced across the globe.

We build a theoretical framework to study the consequences of PI on innovation in the context of an emerging market, such as the Indian pharmaceutical industry. In particular, we analyze the strategic innovative activities of technologically asymmetric firms competing in the home country to understand the impact of PI from an unregulated market where IPR are not protected. We choose to focus on process innovation as we believe it is more appropriate for describing an emerging economy. Indeed, a detailed analysis of the Indian pharmaceutical industry before and after the Patent Act shows a remarkable increase in process innovation whereas no new product has been introduced in this period (Arora, Branstetter and Chatterjee, 2008). Our main contribution lies in introducing features to study PI in such developing markets, namely asymmetric technologies and imperfect IPR enforcement, which together shed light on a number of noteworthy implications absent from previous literature.

More precisely, our model adopts the concept of Leahy and Neary (1997) and Zigic (1998) to build a two stage game where firms invest in cost-reducing innovation and compete in quantity. We build a three country model with two heterogeneous firms located in the home market. The more technologically advanced firm serves a regulated foreign market, whereas the less efficient firm enters an unregulated one. By comparing the optimal R&D investment with and without PI from the unregulated market, we demonstrate that R&D investment by each type of firm crucially depends on the extent of firm heterogeneity and trade costs.

We find that the damages from PI are absorbed by the large firm under free trade, reducing R&D effort by both firms. Trade costs tend to transfer the burden brought about by PI in terms of lower market share to the medium firm. This gives significance to competition in the home market, where PI creates a 'domino' effect inducing the technologically superior firm to strategically increase its R&D. On the other hand, it is the foreign market that plays the principal role in the R&D decision of the medium firm. PI encourages R&D investment by the technologically inferior firm when it increases its foreign sales, which is more likely to occur for low degrees of firm heterogeneity. Finally, we show that tariffs can only make the international exhaustion system welfare optimal if the technology gap between firms is large. This could explain why allowing PI may be justified in India, but not in Europe or the US.

The paper is structured as follows. Section 2 describes the basics of the model.

Section 3 solves the game with and without a ban on PI. Section 4 compares the two scenarios to analyze the incentives to innovate by each firm and derives implications for welfare. Section 5 concludes.

2 The Basic Framework

Consider a home country H, where two heterogeneous firms, L and M, compete. In our example of the Indian pharmaceutical industry, L represents a large-scale company while M represents a medium firm, which obtains its patent through the so called "me-too" drugs, *i.e.* drugs that imitate existing products and consist of only minor modifications.[5] While both firms can invest in cost-reducing R&D activity, they differ in their ability to perform R&D. We assume that L enjoys a superior production technology due to prior experience in the field. We abstract from product differentiation and assume full homogeneity between the two goods in the eyes of consumers.[6]

There are two segmented foreign markets, the North and the South, labeled N and S respectively. IPR are protected in N and H, while S remains an unregulated market. We assume that in addition to the home market, firm L serves the North, where it does not face the threat of imitation.[7] On the contrary, firm M enters the unexploited Southern market, where IPR are not recognized.[8] Local manufacturers in S could hence freely reproduce the drug and sell it not only in S, but also export to H at cost t giving rise to PI. We consider only one firm in S and assume that it does not possess the technology to engage in cost-reducing R&D.[9] The home government has the possibility to ban PI or allow it if it considers that social welfare is damaged by such a practice.

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[5] This is for instance incremental innovation to the product, which has already been invented by the big firm. Thus, no initial large fixed cost are involved.

[6] This is done so without the loss of generality as the results remain the same even when products are not fully homogeneous.

[7] Adding a Northern market into the model also serves to avoid creating an unbalanced market size bias in favor of the M firm.

[8] We can think of FDI as the mode of serving the foreign market. Adding a symmetric fixed cost of FDI will not alter the framework as both L and M have an addtional foreign market both under PI and no PI.

[9] This reflects the fact that foreign goods in less developed countries comprise a large fraction of sales compared to local production (for evidence in Tanzania, see Chaudhuri, 2008). In our model, this comes due to the cost advantage of the medium firm with respect to the less efficient local firm.

We adopt the familiar linear demand function for each country:

$$p_i = a - Q_i \qquad i = H, N, S. \tag{1}$$

For the sake of simplicity, markets are equal in size, captured by a. Depending on whether PI is allowed or not, either two or three firms operate in H. The L firm enjoys a monopoly position in N due to the enforcement of IPR, while the M firm competes with a local firm in S. More precisely,

$$\begin{aligned} Q_H &\equiv \begin{cases} Q_H^{NP} = q_{L_H} + q_{M_H} \\ Q_H^{PI} = q_{L_H} + q_{M_H} + q_{S_H} \end{cases}, \\ Q_N &= q_{L_N}, \\ Q_S &= q_{M_S} + q_{S_S}, \end{aligned} \tag{2}$$

where the first subscript of q denotes the type of firm, and the second the market it serves. Superscripts NP and PI specify the scenario in which parallel imports are banned and allowed respectively.

The cost function for each firm is

$$\begin{aligned} c_L &= c - \frac{1}{2}\sqrt{x_L}\,, \\ c_M &= c - \frac{\beta}{2}\sqrt{x_M}, \\ c_S &= c, \end{aligned} \tag{3}$$

where investment in cost reducing innovation is indicated by x_L and x_M for the L and M firms. Parameter c is the pre-innovation production cost equal across firms. We assume that the lack of IPR protection in S allows the Southern firm to imitate the product, but not the production process. Parameter $\beta \in [0, 1]$ captures the technological difference between the large-scale and the medium firm.[10] Finally, $a > c$, $x_L \leq 4c^2$ and $x_M \leq 4\left(\frac{c}{\beta}\right)^2$ hold to assure non-negative marginal costs after innovation.

The profit function for the L and M firms are

$$\pi_L = (p_H - c_L)q_{L_H} + (p_N - c_L)q_{L_N} - x_L, \tag{4}$$

$$\pi_M = (p_H - c_M)q_{M_H} + (p_S - c_M)q_{M_S} - x_M. \tag{5}$$

The profit of the Southern firm is:

$$\pi_S \equiv \begin{cases} \pi_S^{NP} = (p_S - c_S)q_{S_S} \\ \pi_S^{PI} = (p_S - c_S)q_{S_S} + (p_H - c_S - \tau)q_{S_H} \end{cases}. \tag{6}$$

---

[10] Alternatively, one can think of $(1 - \beta)$ as the technology gap between the two firms.

3 Solving the Game

The two firms in H play a two-stage game: in the first stage they invest in process R&D and in the second stage they compete in quantity *à la* Cournot. We solve the game first in the case where PI is forbidden and then in the case where it is allowed.

3.1 No Parallel Import

We start by considering the case in which PI is banned. Using backward induction, second stage optimal quantities as a function of R&D investment can be computed by taking the first order conditions of (4) and (5) using (1), (2) and (3):

$$\begin{aligned}
q_{L_H}(x_L, x_M) &= \frac{a-c}{3} + \frac{2\sqrt{x_L} - \beta\sqrt{x_M}}{6}, \\
q_{M_H}(x_L, x_M) &= \frac{a-c}{3} + \frac{2\beta\sqrt{x_M} - \sqrt{x_L}}{6}, \\
q_{L_N}(x_L, x_M) &= \frac{a-c}{2} + \frac{\sqrt{x_L}}{4} \\
q_{M_S}(x_L, x_M) &= \frac{a-c}{3} + \frac{\beta\sqrt{x_M}}{3} \\
q_{S_S}(x_L, x_M) &= \frac{a-c}{3} - \frac{\beta\sqrt{x_M}}{6}
\end{aligned} \tag{7}$$

By substituting the above expressions into the original home profit functions, we solve for the optimal R&D investments by maximizing with respect to x_L and x_M to get[11]

$$x_L^* = \left[\frac{6(51 - 14\beta^2)}{1071 - 242\beta^2}\right]^2, \tag{8}$$

$$x_M^* = \left[\frac{221\beta}{1071 - 242\beta^2}\right]^2. \tag{9}$$

Innovation by the L firm is decreasing, while that of M is increasing in β, *i.e.* with a lower technological gap. Substituting $\beta = 1$ in (8) and (9) reveals that the technologically superior firm always invests more in R&D, *i.e.* $x_L^* > x_M^*$.[12]

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[11] For the sake sake of exposition, we can eliminate $(a - c)$ from the final form equations as it appears in a multiplicative form in front of all optimal values of R&D investment, quantity, and profit.

[12] Recall that the L firm enjoys a monopoly position in its foreign market N, whereas the M firm competes in a duopoly in S,

Substituting (8) and (9) in (7), optimal quantities can be calculated and are

$$
\begin{aligned}
q_{L_H}^* &= \frac{3(306-97\beta^2)}{2(1071-242\beta^2)},\ q_{L_N}^* = \frac{2(306-71\beta^2)}{1071-242\beta^2}, \\
q_{M_H}^* &= \frac{306+7\beta^2}{1071-242\beta^2},\ q_{M_S}^* = \frac{7(51-\beta^2)}{1071-242\beta^2}, \\
q_{S_S}^* &= \frac{714-235\beta^2}{2(1071-242\beta^2)}.
\end{aligned} \tag{10}
$$

The derivatives of the optimal quantities w.r.t. β convey the expected results that $\partial q_{L_i}^*/\partial\beta < 0$, $\partial q_{S_S}^*/\partial\beta < 0$ and $\partial q_{M_i}^*/\partial\beta > 0$, for $i = L, M$. Note that a higher β not only reduces the productivity gap between L and M, but also gives M a higher technological edge over the Southern firm in S.

Plugging the optimal R&D investments and quantities back into (4) and (5) yields optimal profits:

$$\pi_L^* = (q_{L_H}^*)^2 + (q_{L_N}^*)^2 - x_L^*, \tag{11}$$

$$\pi_M^* = (q_{M_H}^*)^2 + (q_{M_S}^*)^2 - x_M^*. \tag{12}$$

As with the innovation efforts, profit of the L firm is decreasing, while that of the M firm is increasing in β: $\partial\pi_L^*/\partial\beta < 0$ and $\partial\pi_M^*/\partial\beta > 0$.[13]

Finally, consumer surplus in the home country without PI amounts to

$$CS_H^* = \frac{(q_{L_H}^* + q_{M_H}^*)^2}{2}, \tag{13}$$

and is increasing in β.The direct effect of β on $q_{M_H}^*$ outweighs its indirect effect on $q_{L_H}^*$, *i.e.* $\left|\partial q_{M_H}^*/\partial\beta\right| > \left|\partial q_{L_H}^*/\partial\beta\right|$, as it can be easily ascertained.

3.2 Parallel Import

We now look at the case in which PI is allowed into the home country, where $\tau = t(a-c)$ is the trade cost normalized by the size of the market. As in the previous scenario, second stage optimal quantities can be calculated and are:

$$
\begin{aligned}
q_{L_H}(x_L, x_M) &= \frac{a-c+\tau}{4} + \frac{3\sqrt{x_L} - \beta\sqrt{x_M}}{8}, \\
q_{M_H}(x_L, x_M) &= \frac{a-c+\tau}{4} + \frac{3\beta\sqrt{x_M} - \sqrt{x_L}}{8}, \\
q_{S_H}(x_L, x_M) &= \frac{a-c-3\tau}{4} - \frac{\beta\sqrt{x_M} + \sqrt{x_L}}{8},
\end{aligned} \tag{14}
$$

where $q_{L_N}(x_L, x_M)$, $q_{M_S}(x_L, x_M)$, and $q_{S_S}(x_L, x_M)$ take the same form as in (7).

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[13] All explicit expressions for both regimes are presented in Appendix I.

Next, we derive the optimal R&D investments, which are:

$$x_L^{**} = \left[\frac{2(1008 - \beta^2[298 + 129\tau] + 432\tau)}{3(2448 - 623\beta^2)}\right]^2, \tag{15}$$

$$x_M^{**} = \left[\frac{2\beta(235 + 108\tau)}{2448 - 623\beta^2}\right]^2, \tag{16}$$

Innovation by both firms is always increasing in trade costs τ. Similar to the no PI case, innovation by the L firm is decreasing, that of M is increasing in β, and $x_L^{**} > x_M^{**}$ is always true.

Optimal quantities are in turn:

$$\begin{aligned} q_{L_H}^{**} &= \frac{864 - \beta^2[289 + 215\tau] + 720\tau}{2448 - 623\beta^2}, \; q_{L_N}^{**} = \frac{8352 - \beta^2[2167 + 129\tau] + 432\tau}{2448 - 623\beta^2}, \\ q_{M_H}^{**} &= \frac{8(198 + \beta^2[17 - 24\tau] + 216\tau)}{3(2448 - 623\beta^2)}, \; q_{M_S}^{**} = \frac{3(272 - \beta^2[17 - 24\tau])}{2448 - 623\beta^2}, \\ q_{S_S}^{**} &= \frac{2(408 - \beta^2[143 + 18\tau])}{2448 - 623\beta^2}, \; q_{S_H}^{**} = \frac{1584 - \beta^2[569 - 1353\tau] - 1656\tau}{3(2448 - 623\beta^2)}. \end{aligned} \tag{17}$$

Comparative statics with respect to β replicate the mechanism at work under no PI. Additionally, $\partial q_{S_H}^{**}/\partial\beta < 0$ as entering the home market is easier when the M firm is weak. Clearly, trade costs τ expand output by the home firms and reduce that by the foreign firm: $\partial q_{S_H}^{**}/\partial\tau < 0$, $\partial q_{H_H}^{**}/\partial\tau > 0$, $\partial q_{M_H}^{**}/\partial\tau > 0$.

Notice that there is a prohibitive level of trade costs that blocks PI by making $q_{S_H}^{**} = 0$, which is

$$\hat{\tau} = \frac{(1584 - 569\beta^2)}{3(1872 - 451\beta^2)}. \tag{18}$$

This threshold level of trade costs starts at $\hat{\tau}|_{\beta=0} \simeq 0.28$ and monotonically falls to $\hat{\tau}|_{\beta=1} \simeq 0.24$. Clearly, we are only interested in parameter values of $\tau < \hat{\tau}$, where PI is a feasible option,

Optimal profits for L and M in the presence of PI are:

$$\pi_L^{**} = (q_{L_H}^{**})^2 + (q_{L_N}^{**})^2 - x_L^{**}, \tag{19}$$

$$\pi_M^{**} = (q_{M_H}^{**})^2 + (q_{M_S}^{**})^2 - x_M^{**}. \tag{20}$$

The comparative statics of profits work in the same direction as in the case with no PI, with the addition that profits of both firms are increasing in trade costs τ.[14]

Finally, consumer surplus in the home country is:

$$CS_H^{**} = \frac{(q_{L_H}^{**} + q_{M_H}^{**} + q_{S_H}^{**})^2}{2}, \tag{21}$$

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[14] In a different context under demand uncertainty, Raff and Schmitt (2007) show how PI may incrase the profit of manufacturers.

which is increasing in β and decreasing in τ. The former is because the positive direct effect of β on the output of M dominates the negative indirect effect on the quantity produced by the other firms: $\left|\partial q_{M_H}^{**}/\partial\beta\right| > \left|\partial(q_{L_H}^{**} + q_{S_H}^{**})/\partial\beta\right|$. A similar argument applies to the direct effect of τ on the imports of the Southern firm: $\left|\partial q_{S_H}^{**}/\partial\tau\right| > \left|\partial(q_{L_H}^{**} + q_{M_H}^{**})/\partial\tau\right|$.

4 Analysis and Policy Implication

4.1 The Impact on Innovation

Taking into account the role of both technological heterogeneity between firms and trade costs, we compare the innovation effort carried out by firms across the two regimes. The critical levels of τ above which PI increases cost-reducing R&D by L and M can be found using (8), (9), (15) and (16), and are respectively:

$$\tau_L = \frac{44064 - 31311\beta^2 + 6382\beta^4}{3(1071 - 242\beta^2)(144 - 43\beta^2)}, \tag{22}$$

$$\tau_M = \frac{12546 - 7981\beta^2}{72(1071 - 242\beta^2)}, \tag{23}$$

where $\tau_L < \tau_M < \hat{\tau}$ for $\beta \in [0, 1]$. Hence,

Lemma 1 *Allowing PI is more likely to stimulate innovation by the more technologically advanced firm as* $\Delta x_L = x_L^{**} - x_L^{*} > 0$ *for* $\tau > \tau_L$, $\Delta x_L = x_M^{**} - x_M^{*} > 0$ *for* $\tau > \tau_M$, *where* $\tau_M > \tau_L$.

Proof Directly follows by inspecting (22) and (23). ■

Lemma 1 is illustrated with the aid of Figure 1, where the above threshold values determine the partition of the parameter space. The figure can be divided into three regions: A, B, and C.

Region A depicts a situation of free trade or low values of τ. PI decreases R&D by both firms due to added competition coming from imports of the Southern firm. Introducing PI reduces the market share of L and M in the home market ($\Delta q_{L_H} = q_{L_H}^{**} - q_{L_H}^{*} < 0$ and $\Delta q_{L_M} = q_{M_H}^{**} - q_{M_H}^{*} < 0$), more so the lower the value of β.[15] This is the case because imports from the South are at their highest level when the M firm is relatively inefficient.

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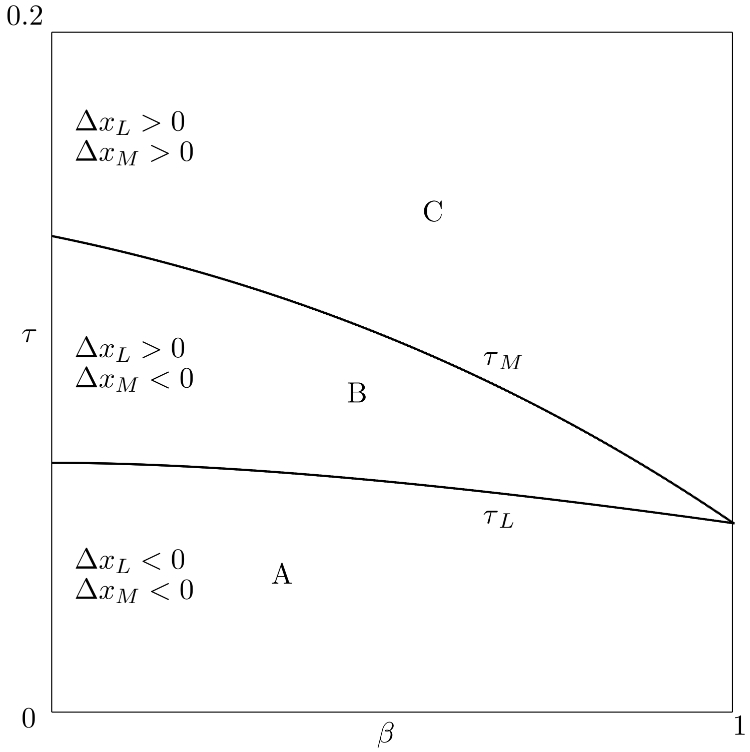
[15] The difference between the variables of interest across the two regimes can be found in Appendix II.

Figure 1: Innovation



Imports tend to absorb more market share from the L firm as long as

$$\tau < \tilde{\tau} \equiv \frac{88128 - 175536\beta^2 + 84593\beta^4}{6(1071 - 242\beta^2)(144 - 151\beta^2)} \iff |\Delta q_{L_H}| > |\Delta q_{M_H}|, \tag{24}$$

with $\tilde{\tau} < \tau_L$ in $\beta \in [0, 1]$.[16] Increasing trade costs shifts the burden of PI from the L to the M firm and this is confirmed by:

$$\frac{\partial(|\Delta q_{L_H}| - |\Delta q_{M_H}|)}{\partial\tau} = -\frac{(144 - 151\beta^2)}{2448 - 623\beta^2} < 0. \tag{25}$$

We can therefore state:

Proposition 1 *While for low τ the reduction in market share brought by PI affects more the L firm, increasing τ transfers the burden to the M firm. Given Lemma 1, when trade costs are sufficiently large so that $\tau > \tau_L$, introducing PI increases R&D investment by the L firm.*

Proof Directly follows from (24) and (25).■

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[16] The threshold value $\tilde{\tau}$ starts at $\tau|_{\beta=0} \simeq 0.1$ and goes to zero for $\beta \simeq 0.9$.

Proposition 1 explains how trade costs affect the market size perceived by each firm, which in turn determines the incentives to engage in process innovation. When trade costs protect L to give a sufficiently large edge over M, the former invests more than under the no PI case. This entails a shift from region A to region B in Figure 1, and occurs when trade costs reach $\tau = \tau_L$.

While allowing PI results in more R&D investment by L in region B, it reduces that by M. Here, the foreign entrant steals more market share from the 'vulnerable' M creating a "domino effect" by making L more aggressive and stimulating its innovation effort. In region B, the Southern market starts to play a crucial role in the R&D decision of M. Interestingly, solving $\Delta q_{M_S} = q^{**}_{M_S} - q^{*}_{M_S}$ for τ unveils that PI induces M to *increase* its output destined for the South when $\tau > \tau_M$. This is more likely to occur when the technology gap between L and M is not significant, since $\partial \tau_M / \partial \beta < 0$.

Using this result along with Lemma 1 confirms that PI encourages also M to devote more resources to R&D exactly when $\Delta q_{M_S} > 0$. It follows that:

Proposition 2 *Allowing PI from the South to the home market increases the output of the M firm for the Southern market along with its R&D efforts when $\tau > \tau_M$. This is more likely for relatively high values of β.*

Proof Directly follows from (23), and Δq_{M_S} evaluated in Appendix II.■

Proposition 2 suggests that PI may instigate M to increase its production for the South and this is viable when it enjoys a large cost advantage with respect to the Southern firm. If so, we move to region C, where a combination of sufficiently high values of β and τ induces more process R&D by both firms under PI. In line with recent PI literature, our results reinforce the claim that PI may actually enhance incentives to innovate by home firms. It remains to evaluate whether PI also improves aggregate welfare in the home country.

4.2 The Impact on Welfare

Let us first consider the case where trade costs do not generate revenues to the home government. It follows that social welfare in H amounts to the sum of consumer and producer surplus: $W_H = CS_H + \Pi_H$, where $\Pi_H = \pi_L + \pi_M$.

First of all, in the admissible range of trade costs $\tau \in [0, \hat{\tau}]$, we can demonstrate that

$$\Delta CS_H = CS^{**}_H - CS^{*}_H > 0, \tag{26}$$

as the entry of a third firm into the home market always makes consumers better off.[17] Together with the results from the previous section on R&D, PI may eliminate the conventional trade-off between consumers' well-being and firms' incentive to innovate (area C in Figure 1). Nevertheless, looking at the supply side yields that PI harms both firms L and M, thus lowering home industry profit:

$$\Delta\Pi_H = (\pi_L^{**} + \pi_M^{**}) - (\pi_L^{*} + \pi_M^{*}) < 0. \tag{27}$$

PI hence benefits consumers, but always at the expense of local firms, regardless of their resulting innovative activities. Weighing the magnitude of consumer gains against producer losses reveals that:

Lemma 2 *Introducing PI always reduces aggregate welfare in the home country as* $\Delta W_H = \Delta CS_H + \Delta\Pi_H < 0$.

Proof see Appendix III. ■

One solution to this dilemma could be the imposition of tariffs on those imports whose legitimacy is the object of our discussion.[18] To investigate this possibility, we simply consider trade costs to be tariffs levied on PI. In this setting, social welfare in H is augmented by tariff revenues

$$T = \tau \cdot q_{S_H}^{**} \tag{28}$$

and is defined by $W_H^T = W_H^{**} + T$. A high tariff rate increases per unit revenue, but reduces the total quantity of imports ($\partial q_{S_H}^{**}/\partial\tau < 0$). Additionally, $\partial q_{S_H}^{**}/\partial\beta < 0$ implies that total revenue is higher the lower the value of β ($\partial T/\partial\beta < 0$).

Given Lemma 2, for PI to increase home welfare it must be true that

$$\Delta W_H^T = T + \Delta W_H > 0. \tag{29}$$

On the one hand, only a high tariff can sufficiently reduce the loss ΔW_H to make this feasible. On the other hand, T is hump-shaped in τ. As $\partial T/\partial\beta < 0$, a relatively large degree of firm heterogeneity is a pre-requisite for tariffs to overturn the detrimental result on welfare. We can deduce that

Proposition 3 *A tariff on PI can make the international exhaustion system welfare improving only if the technology gap between home firms is sufficiently large.*

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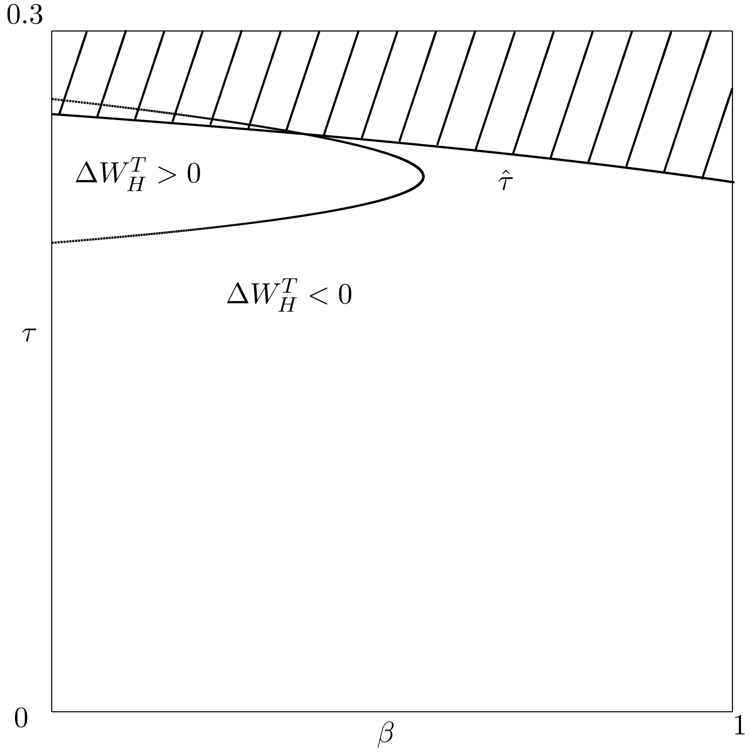
[17] All explicit formulation for the welfare comparison can be found in Appendix III.

[18] Hur and Riyanto (2006) also use trade costs to show how PI can be beneficial for the host country in the presence of a tariff policy. Their analysis however abstracts from the role of innovation.

Proof see Appendix III. ■

The intuition behind Proposition 3 is that social welfare is higher in H under PI when it is possible to simultaneously mitigate the damage to home firms and collect a relatively high tariff revenue. The enforcement of tariffs by the home government is essential to reduce the profit loss ($\partial \left|\Delta\Pi_H\right| / \partial\tau < 0$). However, as noted above, an additional earning is necessary to make PI welfare improving. The tariff revenues can only reach the critical level to satisfy $\Delta W_H^T > 0$ for lor low values of β. The cone-shaped area in Figure 2 represents the parametric region in which social welfare is higher under PI when tariff revenues are taken into account.[19]

Figure 2: Welfare



5 Conclusion

In this paper we have examined the consequences of an international exhaustion system in an emerging economy. In so doing, we have based our model on the Indian

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[19] Recall that above $\hat{\tau}$ the foreign firm does not export to the H market.

pharmaceutical industry, which after the Patent Act 2005 has experienced a surge in PI arriving from markets not yet obliged by TRIPS to enforce IPR protection. A good example is Tanzania, inferior both in terms of technology and IPR enforcement. Such unexploited markets can serve as interesting destinations for less efficient firms in the industry. In the Indian pharmaceutical sector firms can be broadly categorized into two types: (i) a larger company evolving with the aim of taking a lead role on innovation and reach the global market; (ii) a medium firms not as well endowed with technology specializing in producing generics or incremental drugs.

We find that competition in the home market plays a major role in the R&D decision of the large firm. Trade costs transfer the loss brought about by PI from the large to the medium firm. This results in a less aggressive medium firm, which then increases the incentives of the dominant competing firm to innovate. For the medium firm, it is sales in the foreign market that plays the decisive role in its decision to invest in R&D. When a policy favoring PI paradoxically increases its grasp over the Southern market, the medium firm also increases its R&D efforts. This is more likely for low degrees of firm heterogeneity, which also implicitly implies a large enough cost advantage over the Southern firm.

As for welfare, although PI always benefits consumers through lower prices and can increase innovation by both firms, this comes at the expense of profits in a catch up phase where firms seek competitiveness in the global market. Although trade costs create a form of protection against PI, they never fully compensate firms for the losses brought about by such policy. Only when trade costs generate government revenue, i.e. tariffs, PI may also be welfare-enhancing for the home country. This is only a possibility in the presence of large technological asymmetry between firms, which in turn assures sufficient revenues to overturn the welfare results.

We can conclude from our findings that in an emerging industry where the technology gap between firms is large, an international exhaustion system accompanied by tariffs can increase innovation and welfare in the home country. These are the actual conditions that apply to the pharmaceutical industry in India, but not in fully developed economies such as the US or EU, justifying assorted policies observed with regards to PI in different parts of the world.

Appendix I

In Appendix I we report the final form values of equilibrium profits, consumer surplus and total welfare, using (10), (8) and (9) for the PI and (17), (15) and (16) for the no PI case.

No Parallel Import

$$\pi_L^* = \frac{137113\beta^4 - 1023876\beta^2 + 1966356}{(1071 - 242\beta^2)^2}, \tag{A1}$$

$$\pi_M^* = \frac{98\beta^4 - 49555\beta^2 + 221085}{(1071 - 242\beta^2)^2}, \tag{A2}$$

$$CS_H^* = \frac{2(277\beta^2 - 1530)^2}{8(242\beta^2 - 1071)^2}, \tag{A3}$$

$$W_H^* = \frac{8042292 - 3291812\beta^2 + 351739\beta^4}{8(1071 - 242\beta^2)}. \tag{A4}$$

Parallel Import

$$\pi_L^{**} = \frac{26790912 - 4896\beta^2[3034 + 1641\tau + 645\tau^2] + \beta^4[2093927 + 1267554\tau + 471495\tau^2] + 1057536\tau(12 + 5\tau)}{12(2448 - 623\beta^2)^2} \tag{A5}$$

$$\pi_M^{**} = \frac{8501760 - 108\beta^2[21355 + 8408\tau + 10032\tau^2] + 145\beta^4[24\tau - 17]^2 + 497664\tau(11 + 6\tau)}{9(2448 - 623\beta^2)^2} \tag{A6}$$

$$CS_H^{**} = \frac{8\left[1440 - 325\beta^2 - 3\tau(144 - 43\beta^2)\right]^2}{9(2448 - 623\beta^2)}. \tag{A7}$$

$$W_H^{**} = \frac{60244992 - 48\beta^2[581533 + 47646\tau + 120654\tau^2] + \beta^4[3276467 + 215394\tau + 760359\tau^2] + 62208\tau(108 + 181\tau)}{12(2448 - 623\beta^2)^2}. \tag{A8}$$

Appendix II

In this appendix we present the differences in both quantity and investment levels that appear in Section 4.1. The sign of the following expressions has been evaluated in the relevant interval region $\beta \in [0, 1] \cup \tau \in [0, \tilde{\tau}]$:[20]

$$\Delta q_{L_H} = -\frac{396576 - 18\beta^2(13726 - 44945\tau) + \beta^4(41417 - 104060\tau) - 1542240\tau}{2(1071 - 242\beta^2)(2448 - 623\beta^2)} < 0, \tag{A9}$$

$$\Delta q_{M_H} = -\frac{550800 - 342^2(827 - 1824\tau) + \beta^4(19829 - 46464\tau) - 1850688\tau}{3(1071 - 242\beta^2)(2448 - 623\beta^2)} < 0, \tag{A10}$$

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[20] Addional calculations and precise graphical representations for this and the following appendix are available upon request.

$$\Delta q_{M_S} = -\frac{\beta^2[12546-\beta^2(7981-17424\tau)-77112\tau]}{(1071-242\beta^2)(2448-623\beta^2)} > 0 \text{ for } \tau > \tau_M, \tag{A11}$$

$$\begin{aligned} \Delta x_L &= -\frac{4}{9}\left\{\frac{[2203200-9\beta^2(128611+26967\tau)+2\beta^4(15609\tau+75307)+462672\tau]}{(1071-242\beta^2)^2}\cdot\right. \qquad \text{(A12)} \\ &\quad \left.\cdot\frac{[44064-9\beta^2(3479-26967\tau)+2\beta^4(3191-15609\tau)-462672\tau]}{(2448-623\beta^2)^2}\right\} > 0 \text{ for } \tau > \tau_L, \end{aligned}$$

$$\begin{aligned} \Delta x_M &= \frac{3\beta^2[1044378-\beta^2(251423+52272\tau)+231336\tau][12546-\beta^2(7981-17424\tau)-77112\tau]}{(1071-242\beta^2)^2(2448-623\beta^2)^2} \\ &> 0 \text{ for } \tau > \tau_M. \qquad \text{(A13)} \end{aligned}$$

Appendix III

In this appendix we evaluate the sign of the inequalities that appear in Section 4.2. First of all:

$$\begin{aligned} \Delta CS_H &= \frac{1}{72}\left\{\frac{[1101600-18\beta^2(37699-107868\tau)+\beta^4(111487-249744\tau)-3701376\tau]}{(1071-242\beta^2)^2}\cdot\right. \qquad \text{(A14)} \\ &\quad \left.\cdot\frac{[23574240-18\beta^2(581461-107868\tau)+\beta^4(1146913-249744\tau)-3701376\tau]}{(2448-623\beta^2)^2}\right\} > 0, \end{aligned}$$

$$\Delta\Pi_H = -\frac{\left[22552103255040-198288\beta^2(116908819-317210334\tau-152565966\tau^2)\right]+\beta^4\Psi-71355126528\tau(964+447\tau)}{36(1071-242\beta^2)^2(2448-623\beta^2)^2} < 0, \tag{A15}$$

where:

$$\begin{gathered} \Psi=[8944586709615-36\beta^2(43070165909-3350119771944\tau-1715020497036\tau^2)+ \\ +7\beta^4(14660626163-27854561064\tau-14628994380\tau^2)-729\tau(29777635094+14803179645\tau)]. \end{gathered}$$

Moreover,

$$\frac{\partial|\Delta\Pi_H|}{\partial\tau} = -\frac{9994752-144\beta^2(32101+31962\tau)+7\beta^4(79271+83265\tau)+9268992\tau}{6(2448-623\beta^2)^2} < 0. \tag{A16}$$

Taking into account the differences on social welfare, both with and without additional tariff revenues, we obtain:

$$\Delta W_H = -\frac{6378274575360-396576\beta^2(15832613-30793098\tau-6293653\tau^2)+\beta^4\Phi-142710253056\tau(108+181\tau)}{24(1071-242\beta^2)^2(2448-623\beta^2)^2} < 0, \tag{A17}$$

where

$$\begin{gathered} \Phi=[2298423778038-108\beta^2(3567658219-4547941332\tau-13579811366\tau^2)+ \\ +\beta^4(25794292217-25228668432\tau-89059328952\tau^2)-1458\tau(2504840178+6218960351\tau)] \end{gathered}$$

and

$$\Delta W_H^T = -\frac{6378274575360-396576\beta^2(15832613-126405314\tau+23842001\tau^2)+\beta^4\Gamma-47570084352\tau(1072+2109\tau)}{24(1071-242\beta^2)^2(2448-623\beta^2)^2}, \tag{A18}$$

where

$$\Gamma=[2298423778038-36\beta^2(10702974657-85448407748\tau+144996813654\tau^2)+$$
$$+\beta^4(25794292217-191310081776\tau+305858337576\tau^2)-486\tau(38251547402-68627567319\tau)].$$

Finally, we prove Proposition 3 by solving for the value of τ that determines the condition under which PI can be welfare enhancing. From (A18):

$$\begin{aligned} \Delta W_H^T &= 0 \Longrightarrow && \text{(A20)} \\ \tau &= \frac{23807250432-2\beta^2(9011812464-2303178705\beta^2+197634382\beta^4)\pm\sqrt{2\Omega}(2448-623\beta^2)}{6(14577408-7150752\beta^2+870439\beta^4)(1071-242\beta^2)}, \end{aligned}$$

where

$$\Omega=743646624768-2571277828320\beta^2+\beta^4(2017891648980-455187836484\beta^2+27726926171\beta^4).$$

More specifically,

$$\Delta W_H^T \geq 0 \text{ when } t \in [\tau_-, \tau_+],$$

where τ_- and τ_+ are the two threshold values coming from (A20). They can be represented in $\beta \in [0,1]$, giving rise to the cone represented in Figure 3.

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